CLAIMS

What is claimed is:

1. A rotor assembly for an electric motor, the rotor assembly comprising:

a spoke permanent magnet rotor having an axis of rotation, permanent magnet material circumferentially surrounding the axis of rotation to form a circumferentially surrounding portion of permanent magnet material and extending outwardly relative to the axis of rotation to form a plurality of outwardly extending portions of permanent magnet material, and ferro-magnetic material positioned adjacent to the outwardly extending portions of permanent magnet material; and

a shaft supporting the spoke permanent magnet rotor for rotation about the axis of rotation.

2. A rotor assembly as claimed in claim 1 wherein the outwardly extending portions of permanent magnet material extend radially outward to the perimeter of the spoke permanent magnet rotor.

3. A rotor assembly as claimed in claim 1 wherein the ferro-magnetic material includes ferro-magnetic laminations.

4. A rotor assembly as claimed in claim 1 wherein the ferro-magnetic material includes ferro-magnetic powder compacted using a compaction process.

5. A rotor assembly as claimed in claim 1 wherein the permanent magnet material includes permanent magnet powder compacted using a compaction process.

6. A rotor assembly as claimed in claim 1 wherein the ferro-magnetic material includes ferro-magnetic powder compacted using an electromagnetic compaction process, and wherein the permanent magnet material includes permanent magnet powder compacted simultaneously with the ferro-magnetic powder using the electromagnetic compaction process.

7. A rotor assembly as claimed in claim 1 wherein the ferro-magnetic material forms a plurality of pole pieces, and wherein the permanent magnet material includes plastic bonded permanent magnet material injection molded around the pole pieces.

8. A rotor assembly as claimed in claim 1 wherein the ferro-magnetic material forms a plurality of pole pieces, and wherein each of the plurality of pole pieces includes an interface surface that prevents movement between the respective pole piece and the permanent magnet material adjacent to the respective pole piece.

9. A rotor assembly as claimed in claim 8 wherein the interface surface includes a dovetail interface surface that forms a dovetail.

10. A rotor assembly as claimed in claim 8 wherein the interface surface includes a recess interface surface that forms a recess having a main portion and a throat portion, and wherein the throat portion is narrower than the main portion.

11. A rotor assembly as claimed in claim 1 wherein the axis of rotation extends through the permanent magnet material.

12. A rotor assembly as claimed in claim 1 wherein the shaft includes a first stub shaft and a second stub shaft, the first and second stub shafts each having an axis of rotation collinear with the axis of rotation of the spoke permanent magnet rotor, wherein the spoke permanent magnet rotor includes a first end and a second end, and wherein the first stub shaft is connected to the first end and the second stub shaft is connected to the second end.

13. A rotor assembly as claimed in claim 12 wherein the shaft also includes a first end plate and a second end plate, wherein the first end plate is connected to the first end between the spoke permanent magnet rotor and the first stub shaft, and wherein the second end plate is connected to the second end between the spoke permanent magnet rotor and the second stub shaft.

14. A rotor assembly as claimed in claim 1 wherein the circumferentially surrounding portion of permanent magnet material extends from a first radial position to a second radial

position spaced from and outward of the first radial position, wherein the first radial position is positioned substantially adjacent the axis of rotation, and wherein the second radial position is positioned substantially adjacent the radially innermost portion of ferro-magnetic material.

15. A rotor assembly as claimed in claim 1 wherein the circumferentially surrounding portion of permanent magnet material extends from a first radial position to a second radial position spaced from and outward of the first radial position, wherein the first radial position is spaced from the axis of rotation, and wherein the second radial position is positioned substantially adjacent the radially inner most portion of ferro-magnetic material.

16. A rotor assembly as claimed in claim 15 wherein the first radial position is positioned substantially adjacent to an outermost portion of the shaft, and wherein the axis of rotation extends through the shaft.

17. A rotor assembly as claimed in claim 15 wherein the first radial position is positioned substantially adjacent to an outermost portion of a hollow portion, and wherein the axis of rotation extends through the hollow portion.

18. A rotor assembly as claimed in claim 15 wherein the first radial position is positioned substantially adjacent to an outermost portion of a core portion, wherein the axis of rotation extends through the core portion, and wherein the core portion includes at least one of a magnetic material and a non-magnetic material.

19. A rotor assembly for an electric motor, the rotor assembly comprising:

a permanent magnet rotor having an axis of rotation, a center portion of permanent magnet material, a plurality of angularly spaced spoke portions of permanent magnet material extending outwardly from the center portion of permanent magnet material, and ferro-magnetic material positioned between the angularly spaced spoke portions of permanent magnet material; and

a shaft supporting the permanent magnet rotor for rotation about the axis of rotation.

20. A rotor assembly as claimed in claim 19 wherein the center portion of permanent magnet material includes a hollow portion, and wherein the axis of rotation extends through the hollow portion.

21. A rotor assembly as claimed in claim 19 wherein the center portion of permanent magnet material surrounds the shaft, and wherein the axis of rotation extends through the shaft.

22. A rotor assembly as claimed in claim 19 wherein the center portion of permanent magnet material surrounds a core portion, wherein the axis of rotation extends through the core portion, and wherein the core portion includes a non-magnetic material.

23. A rotor assembly as claimed in claim 19 wherein the center portion of permanent magnet material is solid.

24. A rotor assembly as claimed in claim 19 wherein the permanent magnet material and the ferro-magnetic material have an interface therebetween that prevents the ferro-magnetic material adjacent to the interface from moving outwardly during rotation of the spoke permanent magnet rotor about the axis of rotation.

25. A rotor assembly for an electric motor, the rotor assembly comprising:

a spoke permanent magnet rotor having an axis of rotation, permanent magnet material extending outwardly relative to the axis of rotation to form a plurality of outwardly extending spoke portions of permanent magnet material, the permanent magnet material including permanent magnet powder compacted using an electromagnetic compaction process, and ferro-magnetic material positioned adjacent to the outwardly extending spoke portions of permanent magnet material; and

a shaft supporting the spoke permanent magnet rotor for rotation about the axis of rotation.

26. A rotor assembly as claimed in claim 25 wherein the shaft includes a through-shaft assembly having a magnetic through-shaft and a non-magnetic sleeve surrounding at least a portion of the magnetic through-shaft, and wherein the outwardly extending spoke portions of permanent magnet material extend radially outward from the non-magnetic sleeve.

27. A rotor assembly as claimed in claim 25 wherein the ferro-magnetic material includes ferro-magnetic powder compacted simultaneously with the permanent magnet powder using the electromagnetic compaction process.

28. A rotor assembly as claimed in claim 25 wherein the permanent magnet material circumferentially surrounds the axis of rotation to form a circumferentially surrounding portion of permanent magnet material.

29. A rotor assembly as claimed in claim 28 wherein the axis of rotation passes through the permanent magnet material.

30. A rotor assembly as claimed in claim 25 wherein the permanent magnet material forms a center portion of permanent magnet material, and wherein the outwardly extending spoke portions of permanent magnet material extend radially outward form the center portion of permanent magnet material.

31. A rotor assembly as claimed in claim 25 wherein bolts do not extend through the ferro-magnetic material.

32. A method of constructing a rotor assembly for an electric motor, the method comprising:

compacting permanent magnet powder and ferro-magnetic powder using an electromagnetic compaction process to form a spoke permanent magnet rotor, the compacted permanent magnet powder forming a center portion of permanent magnet material and a plurality of spoke portions of permanent magnet material extending outwardly from the center portion of permanent magnet material, and the compacted ferro-magnetic powder forming a plurality of pole pieces, each pole piece being positioned between a respective set of circumferentially adjacent spoke portions of permanent magnet material; and

supporting the spoke permanent magnet rotor on a shaft for rotation about an axis of rotation.

33. A rotor assembly for an electric motor, the assembly comprising:

a spoke permanent magnet rotor having an axis of rotation, permanent magnet material extending outwardly relative to the axis of rotation to form a plurality of outwardly extending spoke portions of permanent magnet material, ferro-magnetic material forming a plurality of pole pieces, each pole piece being positioned between a set of circumferentially adjacent outwardly extending spoke portions of permanent magnet material, the permanent magnet material including injection molded plastic bonded permanent magnet material; and

a shaft supporting the spoke permanent magnet rotor for rotation about the axis of rotation.

34. A rotor assembly as claimed in claim 33 wherein the plastic bonded permanent magnet material is injection molded around the pole pieces in an injection molding process.

35. A rotor assembly as claimed in claim 33 wherein at least one pole piece includes an interface surface that prevents movement between the at least one pole piece and the permanent magnet material adjacent to the at least one pole piece.

36. A rotor assembly as claimed in claim 33 wherein the permanent magnet material circumferentially surrounds the axis of rotation to form a circumferentially surrounding portion of permanent magnet material.

37. A rotor assembly as claimed in claim 36 wherein the axis of rotation passes through the permanent magnet material.

38. A rotor assembly as claimed in claim 33 wherein the permanent magnet material forms a center portion of permanent magnet material, and wherein the outwardly extending spoke portions of permanent magnet material extend radially outward form the center portion of permanent magnet material.

39. A rotor assembly as claimed in claim 33 wherein bolts do not extend through the pole pieces.

40. A method of constructing a rotor assembly for an electric motor, the method comprising:

providing a plurality of ferro-magnetic pole pieces;

injection molding plastic bonded permanent magnet material to form a spoke permanent magnet rotor, the injection molded plastic bonded permanent magnet material forming a center portion of permanent magnet material and a plurality of spoke portions of permanent magnet material extending outwardly from the center portion of permanent magnet material, and each pole piece being positioned between a respective set of circumferentially adjacent spoke portions of permanent magnet material; and

supporting the spoke permanent magnet rotor on a shaft for rotation about an axis of rotation.

41. A method as claimed in claim 40 wherein injection molding plastic bonded permanent magnet material includes injection molding plastic bonded permanent magnet material around the pole pieces.